<u>We claim</u>:

1. A method of determining data flow for a channel having a plurality of subchannels in a multi-carrier system, comprising:

determining data flow for the channel in terms of an input intensity λ_{in}, and a probability of having a frame having no or a correctable number of errors p; and

adjusting channel performance in accordance with the data flow.

2. The method of claim 1 wherein said data flow is determined in accordance with the following relationships:

$$\lambda_{nac} = \lambda_{in} \frac{\left[1-(1-p)^{k}\right](1-p)}{p}$$

$$\lambda_{ti} = \lambda_{in} \frac{1-(1-p)^{k}}{p},$$

$$\lambda_{pout} = \lambda_{in}\left[1-(1-p)^{k}\right],$$

$$\lambda_{rt} = \lambda_{in} \frac{(1-p)\left[1-(1-p)^{k-1}\right]}{p}, \text{ and}$$

$$\lambda_{nout} = \lambda_{in}(1-p)^{k},$$

λ_{nac} represents a negative acknowledgement intensity, k represents a maximum number of transmissions, λ_{ti} represents a transmitter intensity, λ_{pout} represents an intensity of good and correctable frames; λ_{rt} represents a retransmission intensity; λ_{nout} represents an intensity of erroneous frames that are non-correctable after a maximum number of transmissions.

3. The method of claim 2 wherein the data flow is determined by applying said relationships to data flow in a downstream direction, and applying said relationships to data flow in an upstream direction.

4. A method of determining data flow for a channel having a plurality of subchannels in a multi-carrier system, comprising:

determining an upstream data flow;

determining a downstream data flow; and

superimposing the upstream data flow and the downstream data flow to determine a channel data flow.

5. The method of claim 4 wherein the channel uses forward error correction.

6. The method of claim 4 wherein the upstream data flow comprises retransmitting data.

7. The method of claim 4 wherein the downstream data flow comprises retransmitting data.

8. A method of determining throughput in a multicarrier transmission system having a channel, comprising:

generating a representation of the throughput of the channel in a first direction with respect to the throughput of the channel in a second direction; and

determining the throughput of the channel in a first direction with respect to the throughput of the channel in a second direction using the representation.

9. The method of claim 8 wherein the representation is generated in accordance with the following relationships:

$$\frac{M_d}{K_d}\left[\frac{1}{m_d}+\frac{1-p_d}{p_d}\right]\left[1-(1-p_d)^{k_d}\right]\Lambda_d+\frac{N_u}{K_u}\frac{1-(1-p_u)^{k_u}}{p_u}\Lambda_u \le V_u, \text{ and}$$

$$\frac{N_d}{K_d}\frac{1-(1-p_d)^{k_d}}{p_d}\Lambda_d+\frac{M_u}{K_u}\left[\frac{1}{m_u}+\frac{1-p_u}{p_u}\right]\left[1-(1-p_u)^{k_u}\right]\Lambda_u \le V_d,$$

wherein M_d represents a length of an acknowledgment frame in a downstream direction, K_d represents the length of an information field in the downstream direction, m_d represents a number of information frames between positive acknowledgment frames in the downstream direction, p_d represents a probability of an information frame being accepted in the downstream direction, k_d represents a maximum number of transmissions in the downstream direction, Λ_d represents a number of information bits per unit time in the downstream direction, N_d represents a total frame length in the downstream direction, M_u represents a length of an acknowledgment frame in an upstream direction, N_u represents a total frame length in the upstream direction, K_u represents the length of an information field in the upstream direction, m_u represents a number of information frames between positive acknowledgment frames in the upstream direction, p_u represents a probability of an information frame being accepted in the upstream direction, k_u represents a maximum number of transmissions in the upstream direction, Λ_u represents a number of information bits per unit time in the upstream direction, V_u represents a data rate in the upstream direction, and V_d represents a data rate in the downstream direction.

10. A method of determining throughput in a multicarrier transmission system, comprising:

determining the throughput of a channel in an upstream and downstream direction in accordance with the following relationships:

$$H_u = \max \Lambda_u = \min \left\{ \begin{array}{l} V_u \Big/ \left[\dfrac{N_d}{K_d} \dfrac{1-(1-p_d)^{k_d}}{p_d} + \dfrac{M_u}{K_u} \dfrac{V_u}{V_d} \left(\dfrac{1}{m_u} + \dfrac{1-p_u}{p_u} \right) \left(1-(1-p_u)^{k_u} \right) \right], \\ V_u \Big/ \left[\dfrac{M_d}{K_d} \dfrac{V_d}{V_u} \left(\dfrac{1}{m_d} + \dfrac{1-p_d}{p_d} \right) \left(1-(1-p_d)^{k_d} \right) + \dfrac{N_u}{K_u} \dfrac{1-(1-p_u)^{k_u}}{p_u} \right] \end{array} \right\}, \text{ and}$$

$$H_d = \max \Lambda_d = \min \left\{ \begin{array}{l} V_d \Big/ \left[\dfrac{N_d}{K_d} \dfrac{1-(1-p_d)^{k_d}}{p_d} + \dfrac{M_u}{K_u} \dfrac{V_u}{V_d} \left(\dfrac{1}{m_u} + \dfrac{1-p_u}{p_u} \right) \left(1-(1-p_u)^{k_u} \right) \right], \\ V_d \Big/ \left[\dfrac{M_d}{K_d} \dfrac{V_d}{V_u} \left(\dfrac{1}{m_d} + \dfrac{1-p_d}{p_d} \right) \left(1-(1-p_d)^{k_d} \right) + \dfrac{N_u}{K_u} \dfrac{1-(1-p_u)^{k_u}}{p_u} \right] \end{array} \right\},$$

wherein M_d represents a length of an acknowledgment frame in a downstream direction, K_d represents the length of an information field in the downstream direction, m_d represents a number of information frames between positive acknowledgment frames in the downstream direction, p_d represents a probability of an information frame being accepted in the downstream direction, k_d represents a maximum number of transmissions in the downstream direction, Λ_d represents a number of information bits per unit time in the downstream direction, N_d represents a total frame length in the downstream direction, M_u represents a length of an acknowledgment frame in an upstream direction, N_u represents a total frame length in the upstream direction, K_u represents the length of an information field in the upstream direction, m_u represents a number of information frames between positive acknowledgment frames in the upstream direction, p_u represents a probability of an information frame being accepted in the upstream direction, k_u represents a maximum number of transmissions in the upstream direction, Λ_u represents a number of

information bits per unit time in the upstream direction, V_u represents a data rate in the upstream direction, and V_d represents a data rate in the downstream direction.

11. A method of increasing a bit load of a multicarrier system comprising a channel having a plurality of subchannels, comprising:

determining a bit load for at least one subchannel based on a target symbol error rate ε_s, a maximum number of symbol errors that can be corrected t, a number of symbols in an information field K, and a maximum number of transmissions k, and a number of bits per subchannel; and

selecting the maximum number of symbol errors t, the number of symbols in the information field K and the maximum number of transmissions k, such that a coding gain is increased.

12. The method of claim 11 wherein the coding gain is a function of an average number of transmissions for a frame.

13. The method of claim 11 wherein the bit load is determined in accordance with the following relationships:

$$1-\left(1-W(t,K,k)\varepsilon_S^{\frac{1}{(t+1)k}}\right)^{1/\alpha} = \omega(b_i)\left(1-2^{-b_i/2}\right)erfc\left(\sqrt{3\cdot 10^{\gamma_i/10}/\left(2^{b_i+1}-2\right)}\right)\left[2-\left(1-2^{-b_i/2}\right)erfc\left(\sqrt{3\cdot 10^{\gamma_i/10}/\left(2^{b_i+1}-2\right)}\right)\right]$$

wherein b_i represents a number of bits per subchannel, γ_i represents a signal-to-noise ratio at the i-th subchannel, $\omega(b_i)$ represents an average fraction of erroneous bits in a b_i-sized erroneous quadrature-amplitude-modulation symbol, ε_S represents a target symbol error rate, β represents an effect of a descrambler, and α represent a number of bits per code symbol; and

$$W(t,K,k)=\left[\binom{K+C+R-1}{t}\right]^{\frac{1}{(t+1)k}}\left[\binom{K+C+R}{t+1}\right]^{\frac{k-1}{(t+1)k}}$$

C+R represents a number of redundant symbols in an error correction field, and the net coding gain $G_n(t,K,k)$ is determined in accordance with the following relationship:

$$G_n(t,K,k)\equiv\frac{K}{K+C+R}\frac{B_{DMT}(t,K,k)}{\nu}-\frac{K}{K+C}B_{DMT}(0,K,1)$$

ν represents an average number of transmissions, and $B_{DMT}(t, K, k)$ represents a number of bits in a discrete multitone symbol based on the values of t, K and k.

14. The method of claim 13 wherein $\omega(b_i)$ is approximated in accordance with the following relationship:

$$\omega(b_i)=\frac{4}{3+2b_i}\quad .$$

15. The method of claim 13 wherein ε_s is determined in accordance with the following relationship:

$$\varepsilon_S=1-\left(1-\frac{\varepsilon}{\beta}\right)^{\alpha},$$

and ε represents a target bit error rate, α represents a length of a code symbol, and β represents the effect of a descrambler.

16. The method of claim 13 wherein $\omega(b_i)$ is determined in accordance with the following relationship:

$$\omega(b) = \frac{1}{b \cdot 2^b} \sum_{i=1}^{2^b} \sum_{j \neq i}^{\chi_i} \frac{d_H(a_i, a_j)}{\chi_i},$$

b represents a number of bit positions of a quadrature-amplitude-modulation symbol, a_i represents a label for the i^{th} point of a constellation associated with a subchannel, a_j represents a label for the j^{th} point of a constellation associated with a subchannel, and χ_i represents a coordination number of the a_i^{th} point, $d_H(a_i, a_j)$ represents a Hamming distance between respective binary vectors associated with points a_i and a_j.

17. The method of claim 11 further comprising:

determining a total increase in the number of bits to be sent in a DMT symbol ($G_l(t,K,k)$) in accordance with the following relationship:

$$G_d(t,K,k) \equiv B_{DMT}(t,K,k) - B_{DMT}(0,K,1).$$

18. A method of determining an uncoded bit error rate p_b based on a target symbol error rate ε_s and a maximum number of transmissions k, comprising:

determining the uncoded bit error rate p_b based on a weighted series expansion of the target bit error rate ε_s, comprising weights W that are a function of a maximum number of symbol errors that can be corrected t and a number of symbols in an information field K; and

selecting the maximum number of symbol errors t, the number of symbols in the information field K and the maximum number of transmissions k, such that the uncoded bit error rate p_b that produces a symbol error rate that is less than or equal to the target symbol error rate ε_s is largest.

19. The method of claim 18 wherein said weighted series expansion to determine said uncoded bit error rate p_b comprises the following relationship:

$$p_b = 1 - \left(1 - W(t,K,k)\,\varepsilon_S^{\frac{1}{(t+1)k}}\right)^{1/\alpha}$$

wherein

$$W(t,K,k) = \left[\binom{K+C+R-1}{t}\right]^{\frac{1}{(t+1)k}} \left[\binom{K+C+R}{t+1}\right]^{\frac{k-1}{(t+1)k}},$$

C+R represents a number of redundant symbols in an error correction field.

20. A method of selecting transmission parameters a multicarrier system having a channel comprising a plurality of subchannels, comprising:

selecting a number (s) of discrete multi-tone symbols in a forward-error-correction frame, a number (z) of forward-error-correction control symbols in a discrete multitone symbol, and a maximum number of transmissions (k), based on a signal-to-noise ratio and a number of subchannels associated with the signal-to-noise ratio; and

transmitting information in accordance with the selected number (s) of discrete multi-tone symbols, the number (z) of forward-error-correction control symbols in the discrete multitone symbol and the maximum number of transmissions (k).

21. The method of claim 20 wherein said selecting comprises selecting an adjustment value per subchannel based on the signal-to-noise ratio and the number of subchannels associated with the signal-to-noise ratio; and

adjusting a number of bits per subchannel for at least one subchannel in accordance with the adjustment value.

22. The method of claim 20 wherein the signal-to-noise ratio is an average signal-to-noise ratio of the associated number of subchannels.

23. The method of claim 20 further comprising:

storing, in a table, the number (s) of discrete multi-tone symbols in the forward-error-correction frame, the number (z) of forward-error-correction control symbols in the discrete multitone symbol associated with the signal-to-noise ratio, the maximum number of transmissions (k) and the number of subchannels associated with the signal-to-noise ratio, for different values of s, z, signal-to-noise ratios and numbers of subchannels.

24. The method of claim 23 wherein for each value of signal-to-noise ratio and number of bits per subchannel of the table, the associated values of s, z and k are also associated with an adjustment value that provides a maximal net coding gain g_n, such that the associated values of s, z and k is selected from a subset of associated s, z and k values.

25. A method of determining an optimum bit load b per subchannel in a multicarrier system with forward error correction, comprising:

computing one or more values of a maximum number of symbol errors that can be corrected t, a number of symbols in the information field K and a maximum

number of transmissions k to determine the optimum bit load per subchannel in accordance with the following relationship:

$$b = [\gamma + \Phi(\gamma, t, K, k, \varepsilon)]/10\log 2$$

wherein

$$\Phi(\gamma,t,K,k,\varepsilon) = 10\log\left\{10^{-\gamma/10} + \frac{3\log e}{2\log\left[\dfrac{\alpha\langle\omega(b)\rangle\sqrt{8/\pi}}{W(t,K,k)(\alpha\varepsilon/\beta)^{\frac{1}{(t+1)k}}}\right] - \log\log\left[\dfrac{\alpha\langle\omega(b)\rangle\sqrt{8/\pi}}{W(t,K,k)(\alpha\varepsilon/\beta)^{\frac{1}{(t+1)k}}}\right] + \log\left(\dfrac{\log e}{2}\right)}\right\}$$

$$W(t,K,k) = \left[\binom{K+C+R-1}{t}\right]^{\frac{1}{(t+1)k}} \left[\binom{K+C+R}{t+1}\right]^{\frac{k-1}{(t+1)k}},$$

$$\langle\omega(b)\rangle = \frac{1}{b_{max}} \int_1^{b_{max}} \omega(b)\left(1 - 2^{-b/2}\right) db$$

α represents a number of bits per symbol, γ represents a signal-to-noise ratio, ε represents a target symbol error rate, k represents a maximum number of transmissions, C+R represents a number of redundant symbols in an error correction field, b represents a number of bit positions of a quadrature-amplitude-modulation symbol, $\omega(b)$ represents an average fraction of erroneous bits in an erroneous b-sized quadrature-amplitude-modulation symbol, and b_{max} is a maximum number of bit positions of the quadrature-amplitude-modulation symbol per subchannel; and

selecting a bit load per subchannel in accordance with the maximum number of symbol errors that can be corrected t, a number of symbols in the information field K and the maximum number of transmissions k.

26. A method for transmitting data in a multi-carrier system between a downstream station and an upstream station, coupled by a channel having a plurality of subchannels, comprising:

transmitting an information frame from the upstream station;

receiving the information frame at the downstream station;

determining whether the information frame is non-correctable;

transmitting a negative acknowledgement when the information frame is non-correctable; and

transmitting the information frame if the information frame has not be transmitted a predetermined number of times from the upstream station.

27. The method of claim 26 wherein the predetermined number of times is determined in accordance with a measured signal-to-noise ratio value representing at least a subset of the subchannels of the channel, and forward error correction parameters.

28. The method of claim 26 wherein the multi-carrier system is a discrete multi-tone system.

29. The method of claim 26 wherein the discrete multi-tone system comprises the G-lite standard.

30. The method of claim 26 wherein the discrete multi-tone system comprises the G.dmt standard.

31. The method of claim 26 wherein the forward error correction parameters are Reed-Solomon forward error correction parameters.

32. An apparatus for determining throughput in a multicarrier transmission system having a channel, comprising:

means for generating a representation of the throughput of the channel in a first direction with respect to the throughput of the channel in a second direction; and

means for determining the throughput of the channel in a first direction with respect to the throughput of the channel in a second direction using the representation.

33. The apparatus of claim 32 wherein the representation is generated in accordance with the following relationships:

$$\frac{M_d}{K_d}\left[\frac{1}{m_d}+\frac{1-p_d}{p_d}\right]\left[1-(1-p_d)^{k_d}\right]\Lambda_d+\frac{N_u}{K_u}\frac{1-(1-p_u)^{k_u}}{p_u}\Lambda_u \le V_u, \text{ and}$$

$$\frac{N_d}{K_d}\frac{1-(1-p_d)^{k_d}}{p_d}\Lambda_d+\frac{M_u}{K_u}\left[\frac{1}{m_u}+\frac{1-p_u}{p_u}\right]\left[1-(1-p_u)^{k_u}\right]\Lambda_u \le V_d,$$

wherein M_d represents a length of an acknowledgment frame in a downstream direction, K_d represents the length of an information field in the downstream direction, m_d represents a number of information frames between positive acknowledgment frames in the downstream direction, p_d represents a probability of an information frame being accepted in the downstream direction, k_d represents a maximum number of transmissions in the downstream direction, Λ_d represents a number of information bits per unit time in the downstream direction, N_d represents a total frame length in the downstream direction, M_u represents a length of an acknowledgment frame in an upstream direction, N_u represents a total frame length in the upstream direction, K_u represents the length of an information field in the upstream direction, m_u represents a number of information frames between positive acknowledgment frames in the upstream direction, p_u represents a probability of an information frame being accepted in the upstream direction, k_u

represents a maximum number of transmissions in the upstream direction, Λ_u represents a number of information bits per unit time in the upstream direction, V_u represents a data rate in the upstream direction, and V_d represents a data rate in the downstream direction.

34. An apparatus for determining throughput in a multicarrier transmission system, comprising:

means for determining the throughput of a channel in an upstream and downstream direction in accordance with the following relationships:

$$H_u = \max \Lambda_u = \min \left\{ \begin{array}{l} V_u / \left[\frac{N_d}{K_d} \frac{1-(1-p_d)^{k_d}}{p_d} + \frac{M_u}{K_u} \frac{V_u}{V_d} \left(\frac{1}{m_u} + \frac{1-p_u}{p_u} \right) \left(1-(1-p_u)^{k_u} \right) \right], \\ V_u / \left[\frac{M_d}{K_d} \frac{V_d}{V_u} \left(\frac{1}{m_d} + \frac{1-p_d}{p_d} \right) \left(1-(1-p_d)^{k_d} \right) + \frac{N_u}{K_u} \frac{1-(1-p_u)^{k_u}}{p_u} \right] \end{array} \right\}, \text{ and}$$

$$H_d = \max \Lambda_d = \min \left\{ \begin{array}{l} V_d / \left[\frac{N_d}{K_d} \frac{1-(1-p_d)^{k_d}}{p_d} + \frac{M_u}{K_u} \frac{V_u}{V_d} \left(\frac{1}{m_u} + \frac{1-p_u}{p_u} \right) \left(1-(1-p_u)^{k_u} \right) \right], \\ V_d / \left[\frac{M_d}{K_d} \frac{V_d}{V_u} \left(\frac{1}{m_d} + \frac{1-p_d}{p_d} \right) \left(1-(1-p_d)^{k_d} \right) + \frac{N_u}{K_u} \frac{1-(1-p_u)^{k_u}}{p_u} \right] \end{array} \right\},$$

wherein M_d represents a length of an acknowledgment frame in a downstream direction, K_d represents the length of an information field in the downstream direction, m_d represents a number of information frames between positive acknowledgment frames in the downstream direction, p_d represents a probability of an information frame being accepted in the downstream direction, k_d represents a maximum number of transmissions in the downstream direction, Λ_d represents a number of information bits per unit time in the downstream direction, N_d represents a total frame length in the downstream direction, M_u represents a length of an acknowledgment frame in an upstream direction, N_u represents a total frame length in the upstream direction, K_u represents the length of an

information field in the upstream direction, m_u represents a number of information frames between positive acknowledgment frames in the upstream direction, p_u represents a probability of an information frame being accepted in the upstream direction, k_u represents a maximum number of transmissions in the upstream direction, Λ_u represents a number of information bits per unit time in the upstream direction, V_u represents a data rate in the upstream direction, and V_d represents a data rate in the downstream direction.

35. An apparatus for increasing a bit load of a multicarrier system comprising a channel having a plurality of subchannels, comprising:

means for determining a bit load for at least one subchannel based on a target symbol error rate ε_s, a maximum number of symbol errors that can be corrected t, a number of symbols in an information field K, and a maximum number of transmissions k, and a number of bits per subchannel; and

means for selecting the maximum number of symbol errors t, the number of symbols in the information field K and the maximum number of transmissions k, such that a coding gain is increased.

36. The apparatus of claim 35 wherein the coding gain is a function of an average number of transmissions for a frame.

37. The apparatus of claim 35 wherein the bit load is determined in accordance with the following relationships:

$$1-\left(1-W(t,K,k)\varepsilon_S^{\frac{1}{(t+1)k}}\right)^{1/\alpha} = \omega(b_i)\left(1-2^{-b_i/2}\right)erfc\left(\sqrt{3\cdot 10^{\gamma_i/10}/\left(2^{b_i+1}-2\right)}\right)\left[2-\left(1-2^{-b_i/2}\right)erfc\left(\sqrt{3\cdot 10^{\gamma_i/10}/\left(2^{b_i+1}-2\right)}\right)\right]$$

wherein b_i represents a number of bits per subchannel, γ_i represents a signal-to-noise ratio at the i-th subchannel, $\omega(b_i)$ represents an average fraction of erroneous bits in a b_i-sized erroneous quadrature-amplitude-modulation symbol, ε_S represents a target symbol error rate, β represents an effect of a descrambler, and α represent a number of bits per code symbol; and

$$W(t,K,k)=\left[\binom{K+C+R-1}{t}\right]^{-\frac{1}{(t+1)k}}\left[\binom{K+C+R}{t+1}\right]^{-\frac{k-1}{(t+1)k}}$$

C+R represents a number of redundant symbols in an error correction field, and the net coding gain $G_n(t,K,k)$ is determined in accordance with the following relationship:

$$G_n(t,K,k)\equiv\frac{K}{K+C+R}\,\frac{B_{DMT}(t,K,k)}{\nu}-\frac{K}{K+C}B_{DMT}(0,K,1)$$

ν represents an average number of transmissions, and $B_{DMT}(t, K, k)$ represents a number of bits in a discrete multitone symbol based on the values of t, K and k.

38. The apparatus of claim 37 wherein $\omega(b_i)$ is approximated in accordance with the following relationship:

$$\omega(b_i)=\frac{4}{3+2b_i}\qquad.$$

39. The apparatus of claim 37 wherein ε_s is determined in accordance with the following relationship:

$$\varepsilon_S = 1 - \left(1 - \frac{\varepsilon}{\beta}\right)^{\alpha},$$

and ε represents a target bit error rate, α represents a length of a code symbol, and β represents the effect of a descrambler.

40. The apparatus of claim 37 wherein $\omega(b_i)$ is determined in accordance with the following relationship:

$$\omega(b) = \frac{1}{b \cdot 2^b} \sum_{i=1}^{2^b} \sum_{j \neq i}^{\chi_i} \frac{d_H(a_i, a_j)}{\chi_i},$$

b represents a number of bit positions of a quadrature-amplitude-modulation symbol, a_i represents a label for the i^{th} point of a constellation associated with a subchannel, a_j represents a label for the j^{th} point of a constellation associated with a subchannel, and χ_i represents a coordination number of the a_i^{th} point, $d_H(a_i, a_j)$ represents a Hamming distance between respective binary vectors associated with points a_i and a_j.

41. The apparatus of claim 35 further comprising:

means for determining a total increase in the number of bits to be sent in a DMT symbol ($G_l(t,K,k)$) in accordance with the following relationship:

$$G_d(t,K,k) \equiv B_{DMT}(t,K,k) - B_{DMT}(0,K,1) \quad .$$

42. An apparatus for determining an uncoded bit error rate p_b based on a target symbol error rate ε_s and a maximum number of transmissions k, comprising:

means for determining the uncoded bit error rate p_b based on a weighted series expansion of the target bit error rate ε_s, comprising weights W that are a function of a maximum number of symbol errors that can be corrected t and a number of symbols in an information field K; and

means for selecting the maximum number of symbol errors t, the number of symbols in the information field K and the maximum number of transmissions k, such that the uncoded bit error rate p_b that produces a symbol error rate that is less than or equal to the target symbol error rate ε_s is largest.

43. The apparatus of claim 42 wherein said weighted series expansion to determine said uncoded bit error rate p_b comprises the following relationship:

$$p_b = 1 - \left(1 - W\left(t, K, k\right)\varepsilon_S^{\frac{1}{(t+1)k}}\right)^{1/\alpha}$$

wherein

$$W(t,K,k) = \left[\binom{K+C+R-1}{t}\right]^{-\frac{1}{(t+1)k}}\left[\binom{K+C+R}{t+1}\right]^{-\frac{k-1}{(t+1)k}},$$

C+R represents a number of redundant symbols in an error correction field.

44. An apparatus for selecting transmission parameters a multicarrier system having a channel comprising a plurality of subchannels, comprising:

means for selecting a number (s) of discrete multi-tone symbols in a forward-error-correction frame, a number (z) of forward-error-correction control symbols in a discrete multitone symbol, and a maximum number of transmissions (k), based on a signal-to-noise ratio and a number of subchannels associated with the signal-to-noise ratio; and

means for transmitting information in accordance with the selected number (s) of discrete multi-tone symbols, the number (z) of forward-error-correction control symbols in the discrete multitone symbol and the maximum number of transmissions (k).

45. The apparatus of claim 44 wherein said means for selecting comprises selecting an adjustment value per subchannel based on the signal-to-noise ratio and the number of subchannels associated with the signal-to-noise ratio; and

means for adjusting a number of bits per subchannel for at least one subchannel in accordance with the adjustment value.

46. The apparatus of claim 44 wherein the signal-to-noise ratio is an average signal-to-noise ratio of the associated number of subchannels.

47. The apparatus of claim 44 further comprising:

means for storing, in a table, the number (s) of discrete multi-tone symbols in the forward-error-correction frame, the number (z) of forward-error-correction control symbols in the discrete multitone symbol associated with the signal-to-noise ratio, the maximum number of transmissions (k) and the number of subchannels associated with the signal-to-noise ratio, for different values of s, z, signal-to-noise ratios and numbers of subchannels.

48. The apparatus of claim 47 wherein for each value of signal-to-noise ratio and number of bits per subchannel of the table, the associated values of s, z and k are also associated with an adjustment value that provides a maximal net coding gain g_n, such that the associated values of s, z and k is selected from a subset of associated s, z and k values.

49. An apparatus for determining an optimum bit load b per subchannel in a multicarrier system with forward error correction, comprising:
means for computing one or more values of a maximum number of symbol errors that can be corrected t, a number of symbols in the information field K and a maximum number of transmissions k to determine the optimum bit load per subchannel in accordance with the following relationship:

$$b = [\gamma + \Phi(\gamma, t, K, k, \varepsilon)]/10\log 2$$

wherein

$$\Phi(\gamma, t, K, k, \varepsilon) = 10\log\left\{10^{-\gamma/10} + \frac{3\log e}{2\log\left[\dfrac{\alpha\langle\omega(b)\rangle\sqrt{8/\pi}}{W(t,K,k)(\alpha\varepsilon/\beta)^{\frac{1}{(t+1)k}}}\right] - \log\log\left[\dfrac{\alpha\langle\omega(b)\rangle\sqrt{8/\pi}}{W(t,K,k)(\alpha\varepsilon/\beta)^{\frac{1}{(t+1)k}}}\right] + \log\left(\dfrac{\log e}{2}\right)}\right\}$$

$$W(t,K,k) = \left[\binom{K+C+R-1}{t}\right]^{\frac{1}{(t+1)k}} \cdot \left[\binom{K+C+R}{t+1}\right]^{\frac{k-1}{(t+1)k}},$$

$$\langle\omega(b)\rangle = \frac{1}{b_{max}} \int_{1}^{b_{max}} \omega(b)\left(1 - 2^{-b/2}\right)db$$

α represents a number of bits per symbol, γ represents a signal-to-noise ratio, ε represents a target symbol error rate, k represents a maximum number of transmissions, C+R represents a number of redundant symbols in an error correction field, b represents a number of bit positions of a quadrature-amplitude-modulation symbol, $\omega(b)$ represents an average fraction of erroneous bits in an erroneous b-sized quadrature-amplitude-modulation symbol, and b_{max} is a maximum number of bit positions of the quadrature-amplitude-modulation symbol per subchannel; and

means for selecting a bit load per subchannel in accordance with the maximum number of symbol errors that can be corrected t, a number of symbols in the information field K and the maximum number of transmissions k.

50. A method for transmitting data in a multi-carrier system between a downstream station and an upstream station, coupled by a channel having a plurality of subchannels, comprising:

a transmitter to transmit an information frame from the upstream station;

a receiver to receive the information frame at the downstream station, the receiver to determine whether the information frame is non-correctable, and transmit a negative acknowledgement when the information frame is non-correctable;

wherein the transmitter, in response to the negative acknowledgment, transmits the information frame if the information frame has not be transmitted a predetermined number of times from the upstream station.

51. The apparatus of claim 50 wherein the predetermined number of times is determined in accordance with a measured signal-to-noise ratio value representing at least a subset of the subchannels of the channel, and forward error correction parameters.

52. The apparatus of claim 50 wherein the multi-carrier system is a discrete multi-tone system.

53. The apparatus of claim 50 wherein the discrete multi-tone system comprises the G-lite standard.

54. The apparatus of claim 50 wherein the discrete multi-tone system comprises the G.dmt standard.

55. The apparatus of claim 50 wherein the forward error correction parameters are Reed-Solomon forward error correction parameters.